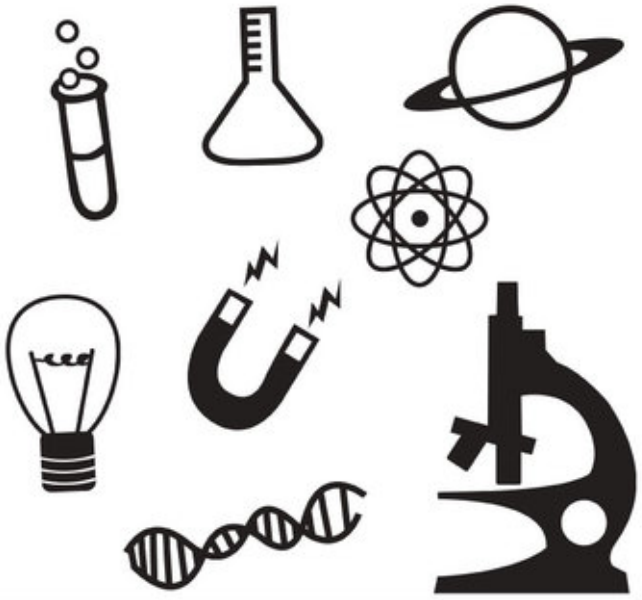
Wentworth Institute of Technology
Department of Sciences

Undergraduate Research Symposium

August 9, 2017



Program Schedule

Welcome

10:15am	Welcome		
10:35am	Keynote Address	Provost	Eric Overström, Ph.D.

Session 1

10:53am	Allison Sirois	Chemistry	Greg Sirokman, Ph.D.
11:06am	Gustavo Arnal	Biology	Ryan Rogers, Ph.D.
11:19am	Muhannad AlQurashi, Brianna Rozell, Jace Valls	Physics	James G. O'brien, Ph.D.
11:32am	Chad Neild, Andrew Deshenes, Matthew Leader	Physics	Franz Rueckert, Ph.D.
11:45am	Samuel Entner	Physics	Douglas Goodman, Ph.D.

Break

Session 2

12:00pm	James Bednar	Physics	Ben Pacek, Ph.D.
12:14pm	Thomas Son	Biology	Nadine Stecher, Ph.D.
12:27pm	TJ Mattos	Physics	Omair Zubairi, Ph.D
12:40pm	Tanner McFarland, Jake Loewen	Chemistry	Greg Sirokman, Ph.D.
12:53pm	Michaella Moretto	Biology	Kimberly Foster, M.S.

Break

Session 3

1:08pm	Thomas L. Chiarelli	Physics	James G. Obrien, Ph.D.
1:21pm	Kathryn Rooney	Chemistry	Greg Sirokman, Ph.D.
1:34pm	Tanner McFarland	Biology	Ryan Rogers, Ph.D
1:47pm	Scott Moir	Physics	Omair Zubairi, Ph.D.

Methanol Recovery from Biodiesel

Allison Sirois, Department of Mechanical Engineering
Greg Sirokman, Ph.D., Department of Sciences

The purpose of research was to increase the cost efficiency of producing biodiesel by recovering excess methanol from the reaction. An initial distillation of the glycerol byproduct was performed to determine the exact components of the glycerol. Then, an NMR was done to prove that the distillate was methanol. A larger sample of glycerol distillations were then performed to scale how much methanol was recoverable from glycerol per batch of biodiesel. A separate distillation of biodiesel was done to measure the existence of methanol in the biodiesel. In the end, the amount of recoverable methanol in a batch of biodiesel was determined in order to preliminarily substantiate the use of recovered methanol to increase cost efficiency.

Investigating Size Variance Between *yw* and *InR* mutant Third Instar Larvae Using ImageJ

Gustavo Arnal, Department of Biomedical Engineering
Ryan Rogers, Ph.D., Department of Sciences

Mutant *Insulin Receptor (InR)* female *Drosophila melanogaster* flies are considered dwarfs due to reduced growth and experience up to an 85% increase in longevity (Tatar et al. 2001) compared to *yellow white (yw) D. melanogaster* flies. For this reason, it was of interest to investigate if this growth deviance occurred in the developmental stages of the flies, specifically in the third instar larvae stage. To determine the optimal concentration of sucrose, toxicity assays were conducted and 10% sucrose determined. As part of this experiment, *yw* and *InR* mutant flies were placed in vials containing food of two different sucrose concentrations, 0% and 10%. Multigenerational exposure to elevated metabolic substrate was studied for both types of flies. Size measurements were performed at regular time intervals using a self-developed method which involves image processing with ImageJ. Preliminary results show a significant growth of larvae across generations, but no significant changes in size between *yw* and *InR* mutant fly larvae, or between metabolic substrate concentrations. Results suggest that dwarfs *InR* female flies begin exhibiting variation in their size post metamorphosis, and a 10% increase of metabolic substrate does not impact their physical growth during development.

Conformal Gravity Across Three Scales of Galactic Mass

Muhannad AlQurashi , Department of Mechanical Engineering
Brianna Rozell, Department of Biomedical Engineering
Jace Valls, Department of Biomedical Engineering
James G. O'Brien, Ph.D., Department of Sciences

Ever since Fritz Zwicky discovered the missing mass problem, there has been a search for a reason for what could be causing the disconnect between theory and reality in the cosmos. Dark Matter is one of the most popular theories and there are others such as MOND. However, they lack something, universality. Physics is a field dedicated to explaining our universe and everything in it, using an equation or equations that work for everything they describe. Most alternative theories to gravity cannot do this. Conformal Gravity, can. Using virial approximation we solve the missing mass problem by calculating the mass-to-light ratio of celestial objects using conformal gravity and compare it to the standard gravitational theory. We do not do this for only one size or type of celestial but across a wide range of sizes and types. Our calculations show that expected mass-to-light can be estimated without the need for dark matter. Conformal Gravity has been building its case and in this paper we show that it is the only alternative theory to gravity that can be applied across all scales of celestial mass.

Characterizing High Temperature Superconductors

Chad Neild, Department of Interdisciplinary Engineering
Andrew Deschenes, Department of Interdisciplinary Engineering
Matthew Leader, Department of Interdisciplinary Engineering
Franz Rueckert, Ph.D., Department of Sciences

Superconductivity describes an object with no electrical resistance at low temperatures. This effect is explained to some extent in quantum physics by the Bardeen-Cooper-Schrieffer (BCS) theory, however, the details of high temperature superconductors are not yet fully understood. This experiment is the second stage of an ongoing research process at Wentworth. Previous groups used WIT facilities to produced samples of both Bi2Sr2CaCu207 (BSSCO) and YBa2Cu3O7 (YBCO) with variations in composition and procedure to improve the quality. Our goal was to develop a way to evaluate these samples by designing and building a resistance vs temperature device. An important feature of any superconductor is the critical temperature (TC) where zero resistance is reached. Our device measures this using a 4-wire circuit with a set current traveling through the material. The voltage is monitored with National Instruments data acquisition board while an R type thermocouple is used to measure the instantaneous temperature of the superconductor. Ohm's law is used to calculate the resistance. The sample is cooled using liquid nitrogen and many measurements are made as it warms to room temperature. The data is recorded through a python script and put into an excel document to plot the resistance as a function of temperature. TC can then be determined from the graph. Our talk will describe our design considerations and the process of building and testing the device.

Magneto-Optical Trap Thermometry

Samuel Entner, Department of Applied Mathematics
Douglas Goodman, Ph.D., Department of Sciences

Magneto-optical trapping and cooling is fundamental to the study of ultracold gases, often serving as the workhorse for many cutting-edge, cold-atomic-physics applications. The magneto-optical trap creates a cold (~ 100 uK) localized cloud of neutral atoms, therefore, characterizing the temperature of the cloud is an essential task. This talk will describe the development of a modified release-and-recapture technique for measuring a trapped sodium cloud's temperature via spatiotemporal fluorescence imaging (STFI). We will highlight the logistics behind this approach, including simulations, theory, and automation of the data acquisition process.

A Comprehensive Investigation of Exoplanet Candidates in Kepler's Eclipsing Binaries

James Bednar, Department of Electromechanical Engineering
Ben Placek Ph.D., Department of Sciences

An extra-solar planet (exoplanet) is any planet that orbits a star other than our Sun. Much of contemporary exoplanet research centers around the transit method, which entails monitoring the brightness of a star over time and characterizing periodic dimming events called transits. A transit occurs when a planet crosses in front of its host star with respect to our line of sight, which blocks a portion of the starlight, and translates into a dimming in brightness of the host star as seen from Earth. Just as planets can transit stars, stars can eclipse each other in binary star systems. This work represents a search for exoplanets in binary star systems through the method of transit timing.

Due to the nature of binary systems, changes in the times at which transit events occur and the corresponding durations of such transits occur quite predictably. These variations in transit time and duration are referred to as transit timing variations (TTVs) and transit duration variations (TDVs). Gravitational interactions among the stars and planets in systems with multiple objects induce perturbations, which in turn cause TTVs and TDVs. By analyzing the transit times and durations of eclipsing binary stars, it is possible to infer the masses and orbital distances of any unseen exoplanets that may be present within the system.

Through this research, approximately 16 promising binary systems that closely mimicked theoretical models were identified out of approximately 300 light curves analyzed. This work serves as the first known comprehensive retrieval of transit times and durations for the entirety of the eclipsing binary library collected by the Kepler Space Telescope. Future directions are currently being explored to build upon this foundation such as an N-body simulation. This is being implemented in MATLAB, with the hope that it can eventually be utilized as a vehicle to model and confirm the TTV/TDVs of exoplanets in binary systems.

Electrophysiological Measurements of Mouse Cortical Neurons

Thomas Son, Department of Biomedical Engineering
Nadine Stecher, Ph.D., Department of Sciences

The purpose of this project is to develop a lab in which students become familiar with the nuances of lab work, and the use of lab instruments. From this, they will learn how to use their knowledge to design experiments to further their own knowledge. In this study, we plan to measure the electrophysiological properties of the neurons from mouse cortical neurons. Neurons use electrical impulses to communicate information. Within the cell membrane, ion channels facilitate the flow of ions. The passage of sodium and potassium ions shifts the electrical charge between the intracellular and extracellular fluid, creating an electrical signal. Electrophysiological experiments are to be conducted using the whole-cell patch clamp method. This involves the use of a micro-furnished pipette fitted with a silver-silver electrode, and inserting it into the cell soma. To mimic the natural environment of neurons, control ionic solutions are filled within the pipette and the fluid surrounding the cell. Control measurements for the membrane potential, threshold voltage and duration of the action potential will be the first priorities. The results obtained from the control experiments will then be compared to the results of measurements from modified environments. To understand the effects of differences of ion concentration on neuron physiology, modifications will be made to the ion concentration of the extracellular fluid and fluid within the pipette.

Numerical Simulations of Exoplanets

T.J. Mattos, Department of Applied Mathematics
Omair Zubairi, Ph.D., Department of Sciences

Exoplanets are planets which are orbiting other stars than our Sun. Over the last two decades about 3600 exoplanets have been discovered using ground and space telescopes. The recent discoveries of these mysterious planets are the first steps towards exosolar space exploration. In this project, we are studying exoplanets from a different perspective by numerically modeling the stellar structure of these objects. By computationally solving a set of coupled ordinary differential equations which govern the stellar structure of a spherically symmetric astrophysical object, we obtain a set of stellar properties such as masses and radii along with pressure and density profiles. We then investigate these properties with observational data and make comparisons.

ASTM Testing of Biodiesel

Tanner McFarland, Department of Biomedical Engineering
Jake Loewen, Department of Biomedical Engineering
Greg Sirokman, Ph.D., Department of Sciences

Biodiesel fuels have been used for over a century [1] and have been steadily increasing in popularity. It's a relatively inexpensive fuel source which can be synthesized from waste vegetable oil taken from fast food restaurants and dining halls, oil that would have otherwise been disposed of. Biodiesel fuels are used in diesel engines which combust the fuel using compression, exactly like regular diesel fuel. However, combusting any fuel gives off byproducts and pollutants into the air such as nitric oxides [2] which are harmful to the environment. The use of biodiesel decreases the amount of pollutants given off, but the exhaust for biodiesel fuels must conform to American Society for Testing and Materials (ASTM) standards. These standards are designed to test the fuel to ensure the exhaust is clean enough to be output into the environment and will be able to function in a diesel engine without negative ramifications. Additionally, the standards specify the amount of certain elements that are acceptable to remain within the finished biodiesel product. Along with providing numerical specifications, the ASTM standards detail different test methods that are the required procedural templates for testing the sample. Following these methods, the group was able to test and collect data on multiple biodiesel specifications. The most significant goal is to produce fuel in the Wentworth biodiesel lab that conforms to ASTM standards which can be used by Wentworth employees to fuel campus vehicles. First, a list of standards needs to be compiled relevant to the standards of biodiesel fuels from available ASTM volumes. Ideally, each standard would be tested in the Wentworth chemistry labs. Some equipment needed for the tests is not available at WIT and samples may need to be sent out for testing. Tests that can be completed on campus will be completed and compared to ASTM standards and requirements. Standard operating procedures for synthesizing the biodiesel fuel from used vegetable oil provided by the dining hall, to the final product will be reviewed and possibly modified pending the results of each standards testing to produce a fuel which can be used by Wentworth. Each test will be completed conforming to the test methods outlined in each respective standard. Water and Sediment along with Cloud Point have been completed thus far. Copper Strip Corrosion and Viscosity will also hopefully be accomplished by the conclusion of the semester. The group took vegetable oil from the cafeteria at Wentworth and synthesized it into biodiesel using potassium hydroxide as a catalyst. Multiple washes were completed on the sample and the sample was heated to 150C before testing of standards to completely rid the sample of water. The biodiesel was then tested up against ASTM standards and the results were recorded. The work done this semester will move future researchers at Wentworth closer to producing ASTM approved biodiesel. This will allow the institution to create renewable energy from the used vegetable oil generated in the dining hall.

Genetically engineered plasmid to express green fluorescent protein using pBAD promoter

Michaella Moretto, Department of Biomedical Engineering
Kimberly Foster, M.S., Department of Sciences

Currently Wentworth pays for the plasmid pGlo to use in the gene expression laboratory sequence. This sequence takes place in the molecular biology course and is a great learning tool for the students. In order to be more cost effective, a new plasmid was engineered to replace pGlo. The plasmid was constructed in the Biology lab using PCR molecular cloning techniques. The results are a plasmid that, with further testing, can be used in replace of pGlo indefinitely.

A Conformal Gravity Approach to Universal Centripetal Accelerations of Spiral Galaxies}

Thomas L. Chiarelli, Department of Electromechanical Engineering
James, G. O'brien, Ph.D., Department of Sciences,

In a recent article, McGaugh et al. explored the universal nature of centripetal accelerations of spiral galaxies as a new natural law. Their work showed a strong correlation between observed centripetal accelerations and those predicted by luminous matter alone. They explore a fitting function, which can serve to constrain the amount of dark matter in spiral galaxies in a uniform manner, which is completely determined by the baryons. Another possible explanation explored by the authors however, is that new physics could be responsible for the close correlation between observation and luminous matter alone. In this work, we show that conformal gravity, a fourth order renormalizable metric theory of gravity, which has enjoyed success in fitting galactic rotation curves can provide a solution to the universal centripetal accelerations observed by McGaugh et al., without the need for any dark matter.

Synthesis and isolation of iron- osmium- and ruthenium-metalloporphyrins

Kathryn Rooney, Department of Biomedical Engineering
Greg Sirokman, Ph.D., Department of Sciences

Tetra(4-methylphenyl)porphyrin (TPP) was synthesized in bulk and metallated with iron, osmium, and ruthenium chloride hydrates under reflux. The metalloporphyrin products were segregated from the reaction solutions using column isolation and rotary evaporation. The products were then characterized through nuclear magnetic resonance (NMR) and ultraviolet-visible (UV-vis) spectroscopy as well as thin-layer chromatography (TLC).

The Effects of Sugar Consumption on *InR* Expression and Mitochondrial Metabolism in Multiple Generations of *Drosophila melanogaster*

Tanner McFarland, Department of Biomedical Engineering
Ryan Rogers, Ph.D., Department of Sciences

Augmented sugar consumption has been linked to obesity and numerous other health concerns. One of the most important organic molecules due to its function in cellular respiration is glucose, it plays a key role in the formation of ATP which our bodies use for energy. In humans, insulin is a key hormone which helps to regulate blood sugar. However, Diabetes is a disease where a patient does not produce enough insulin, or cannot effectively use their own insulin to metabolize the sugar. People with diabetes require an artificial insulin to metabolize sugar and keep blood sugar levels within a reasonable range. *InR* flies have a similar disorder, they cannot produce insulin so they have little to no way to cope with added sugar in their diet. It is hypothesized that *InR* control flies will have a shorter lifespan in both control and experimental populations compared to yellow-white flies, decreased mobility compared to *yellow-white* flies, and a decreased metabolism. In order to study the effects of prolonged sugar consumption, the lifespan of *Drosophila melanogaster* was studied in control populations, both *yellow-white* and *InR*, and both populations, *yellow-white* and *InR* given a 10% sucrose solution in place of water. Additionally, mitochondrial metabolism will be studied using qPCR to look for the expression or suppression of specific genes within the fly's RNA, and flies will be put through a mobility assay to relate mobility to change in metabolism. Flies from multiple generations (1-3) will all be tested to gain an understanding of how sucrose effects metabolism, mobility, and lifespan across generations. Generation one lifespan studies have been completed and show in control populations the survival rate is very similar between *yellow-white* and *InR* populations. The augmented sucrose populations showed males having a higher survival rate over females for both *yellow-white* and *InR* populations. The results may illustrate new connections between sucrose intake and mitochondrial metabolism disorders.

Numerically computed trans-lunar injection model

Scott Moir, Department of Electrical Engineering & Technology
Omair Zubairi, Ph.D., Department of Sciences

The goal of this research project was to successfully numerically model the launch of a satellite from the Earth to the Moon following a similar trajectory to that of the Apollo missions. The equations of motions (EoM) which govern orbital mechanics in this framework were numerically solved in FORTRAN via Runge-Kutta methods. The patched conic approximation method was used to simplify the two-body (Earth and Moon) nature of the problem. Ultimately, the solutions to the EoMs allowed us to plot a successful lunar orbit in the x-y plane. For future work on this project, we plan to improve the models accuracy by taking account the Moon's orbital trajectory.

Thank you for attending!